NRSP_Temp13
Artificial Intelligence for Agricultural Autonomy

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Need for Autonomous Systems

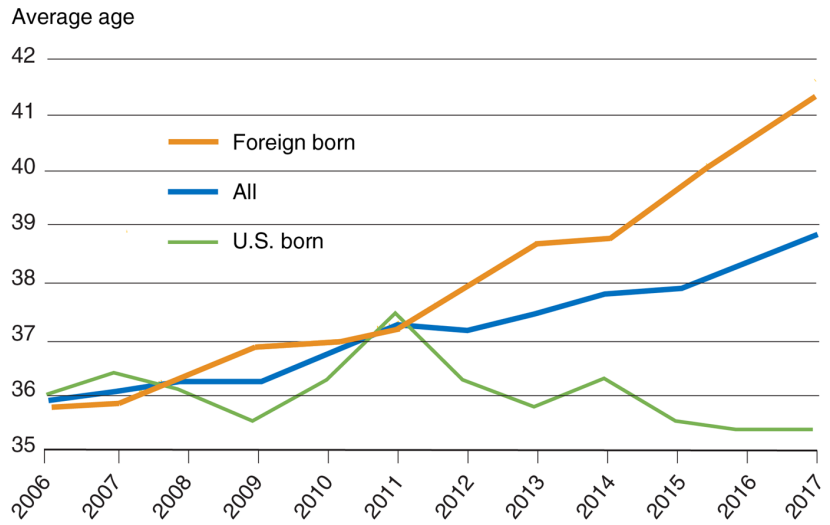
- Labor issues
- Safety and efficiency
- Higher precision and optimization

Requirements for Autonomous Systems

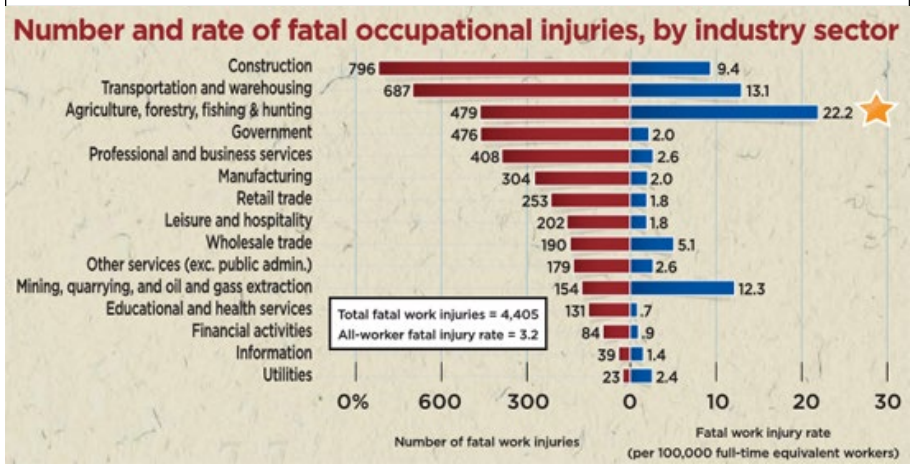
- Sensing (new smart sensors are available)
- Analytics (AI: needs vast amounts of data!)
- Actuation (wheels with motors, robotic arms, etc.)

In case you missed it . . .

Average age of U.S. hired farm laborers by place of birth, 2006–17

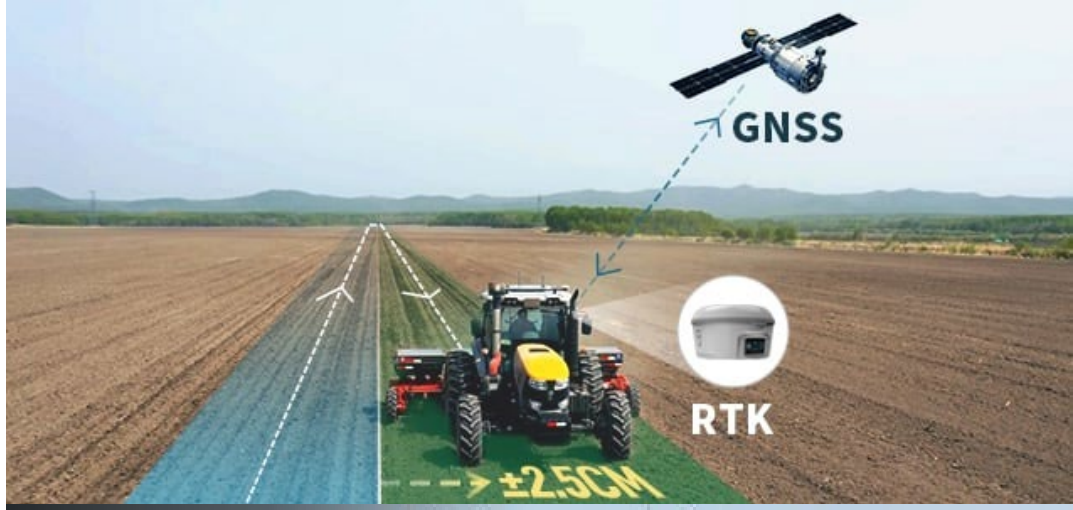


Source: USDA, Economic Research Service using data from the U.S. Census Bureau, American Community Survey, 2006–17.



Simple Solutions Being Developed

- Simple operations like tillage
- Autonomy in large flat fields; limited interaction with crops
- GPS and inertial autonomous guidance



But Complex Solutions Need A Boost

- Complex operations like fruit harvesting and pruning
- Autonomy in semi-structured fields; complex interaction with crops
- Advanced perception, decision-making, and actuation

Robotics Has Flourished in Industry

- Autonomous mobile robots in warehouse
- Robotic arms for manufacturing
- Robotic arms and grippers for medical surgery

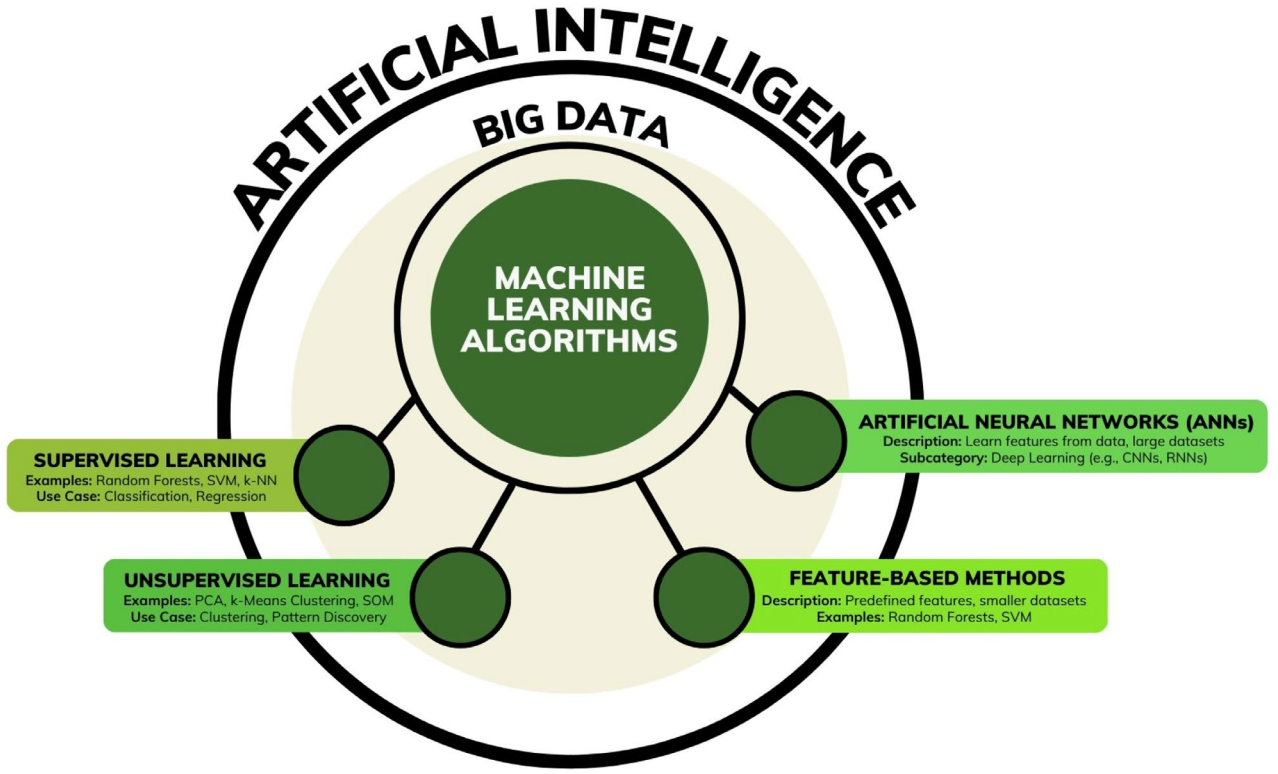
Agriculture is Much More Complex Than Industry

- Uncontrolled environment (temperature, precipitation, topography, geography, dynamic obstacles, dirt, farming systems, etc.)
- Many more variables and tasks

Our Specific Problems

- R&D on Agricultural Autonomy suffers from:
  - Gaps in data
  - Gaps in AI model development
  - Minimal collaboration

PlantVillage Dataset: images of healthy and diseased plant leaves
Agriculture-Vision Dataset: aerial images of agricultural fields with anomalies (weeds, dry areas and insect damage)
Open Images Dataset for Agriculture: images of agricultural objects including machinery, farm animals, and crops
DeepWeeds Dataset: images of weeds in Australia
CropDeep Dataset: images for crop recognition and disease detection



Objectives

1. To ***develop large, comprehensive, open-source datasets*** that make benchmark data available to researchers nationwide and span a wide range of agricultural-autonomy applications. Specific tasks are as follows:
    a. Crop Selection and Field Data Collection
    b. Enhancing Data Variability, Quality and Access
    c. Data collection and sharing standards
2. To ***build a formal collaboration with computer scientists to develop AI algorithms and architectures*** that account for the fusion of data on different geospatial and temporal time scales, that use feature engineering to maximize algorithm efficiency, and that use data that are practically available to growers and agronomic consultants. Specific tasks are as follows:
    a. Models for autonomous navigation in agricultural fields
    b. Models for automating labor-intensive agricultural operations
    c. Partnership with computer scientists to develop robust AI models

Related multistate projects

- W4009 Integrated Systems Research and Development in Automation and Sensors for Sustainability of Specialty Crops
  - Technical Lead: Vougioukas
- S1090 AI in Agroecosystems: Big Data and Smart Technology-Driven Sustainable Production
  - Technical Lead: Won Suk (Daniel) Lee
- S1098 Autonomy for Agricultural Production, Processing, and Research to Advance Food Security through Sustainable and Climate-Smart Methods
  - Technical Lead: Thomasson

Advantages of national effort

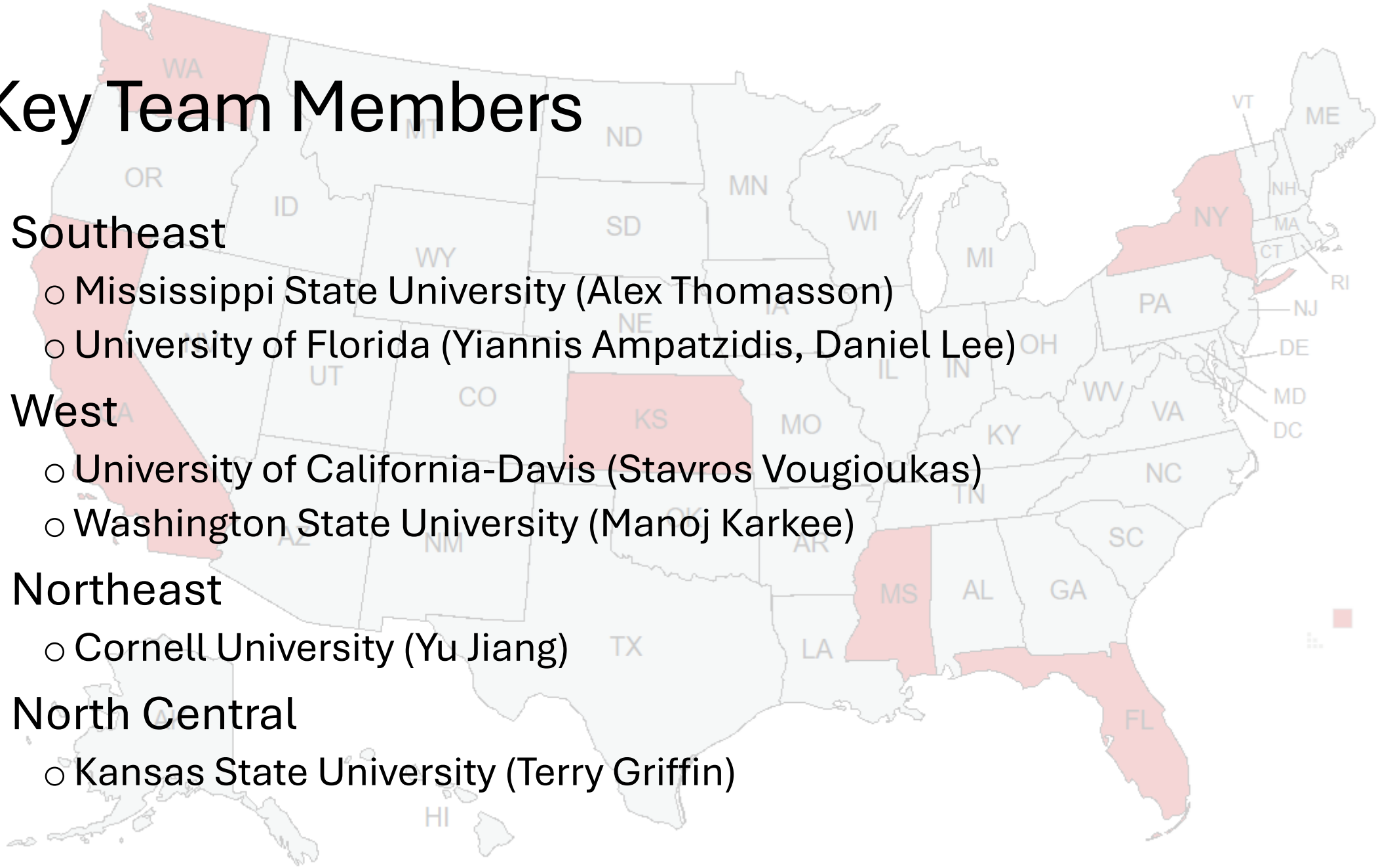
- Agricultural autonomy faces **similar challenges across geographies** and crops (e.g., variations in lighting and weather, occlusion due to foliage, unstructured terrain, etc.)
- The creation of **data-collection standards**, along with the development of large open-source databases and customized AI solutions, will benefit researchers in this field across the country
- There is a need for **much greater collaboration** across the country, as well as a dedicated effort to facilitate related multistate projects
- A **consistent, concerted effort with national leadership**, and funding to maintain that effort, is required to achieve coordinated progress in AI for autonomous systems to overcome the most challenging aspects of the problem.
  - obstacle avoidance and safety including consideration of negative obstacles
  - object detection considering occlusion
  - standardization of data collection
  - robust algorithms tailored to autonomous agricultural systems
  - etc.

Impacts

- Accelerate the progress of research in agricultural autonomy
- Move from solving very simple tasks to solving complex tasks that are the most dependent on the waning labor supply
- Provide solutions to many agricultural labor issues
- Add safety, efficiency, and quality-of-life improvements to many jobs currently requiring humans to do dull, dirty, and dangerous tasks
- Open new avenues for a greater level of precision in the optimization of crop management

Key Team Members

- Southeast
  - Mississippi State University (Alex Thomasson)
  - University of Florida (Yiannis Ampatzidis, Daniel Lee)
- West
  - University of California-Davis (Stavros Vougioukas)
  - Washington State University (Manoj Karkee)
- Northeast
  - Cornell University (Yu Jiang)
- North Central
  - Kansas State University (Terry Griffin)



Budget

- MSU will receive all funds and subcontract other institutions.
- Individual institutional yearly budgets include salaries and fringe benefits, student and postdoctoral researcher support, travel, and supplies:
  - MSU $98k
  - WSU $75k
  - UF $158k
  - UCD $88k
  - CU $37k
  - KSU $44k
- The requested funds support activities that are challenging to support with other funding, such as the development and sharing of data collection standards, open-source datasets and code libraries, researcher collaboration, and stakeholder engagement.

Business Model

- This NRSP will provide an opportunity to **leverage funds from other sources** to support critical agricultural autonomy research at the national level

  - Individually, the members of the leadership team are very successful in securing federal, state, commodity board, and industry grants, as well as getting support from regional experiment stations and private donors

  - The leadership team has started – and will continue - to build joint proposals to develop agricultural autonomy technologies and support related activities